

Remarks/Arguments

Reconsideration of this application is requested.

Extension of Time

A request for a three month extension of time for response to the Office Action mailed on November 7, 2005 is enclosed. The extended period for response expires on Monday, May 8, 2006.

Claim Status

Claims 33, 34, 41-43, 48, 49 and 56-58 were presented. Claim 33 is amended. Claims 34 and 49 are canceled, without prejudice. New claims 59-66 are added. Thus, claims 33, 41-43, 48 and 56-66 are now pending.

Claim Rejections – 35 USC 103(a)

Claims 33, 34, 41-43, 48, 49 and 56-58 are rejected under 35 USC 103(a) as obvious over Mountsier (US 5,810,933) in view of Moslehi (US 5,936,829) and Sexton (US 6,377,437). In response, independent claim 33 is amended to clearly distinguish over Mountsier, Moslehi and Sexton. In particular, claim 33 as amended now includes the following limitations:

- a) introduction of helium gas into the heat-exchange concave; and*
- b) the heat-exchange concave has a depth in a range of 1 to less than 20 μm .*

The limitation of a heat-exchange concave having a depth of 1 to less than 20 μm was added to claim 33 in the amendment of February 3, 2005 and subsequently deleted. However, the combination of helium gas introduced into a heat-exchange concave having the claimed depth has never been present in the claims and distinguishes the invention from the references of record. Previous Actions have relied on Mountsier's Fig. 9 as disclosing a heat-exchange concave having a depth of 1 to less than 20 μm . However, the data shown in Mountsier's Fig. 9 is for *hydrogen* gas (column 7, lines 31-32), not for helium gas as claimed. Thus, the data presented in Fig. 9 is not applicable to use of helium gas. As discussed in detail below, the introduction of helium gas into a heat-exchange concave having a depth of 1 to less

than 20 μm provides critical and unexpected advantages and is not rendered obvious by Mountsier's introduction of hydrogen gas into a concave.

With respect to Mountsier's Fig. 9, the designation "Free-molecular path regime" is provided but not explained. Applicant assumes this terminology to refer to the mean free path of the hydrogen gas and thus the regime where the gap is within the mean free path of hydrogen. In this regard, page 6-46 of the CRC Handbook of Chemistry and Physics, 2000-2001 Edition is enclosed and listed on the attached IDS. As is known, the mean free path of helium is longer than that of hydrogen because helium has a molecular diameter smaller than that of hydrogen. Transitions from Mountsier's free-molecular path regime to the illustrated transition and continuum regimes (Fig. 9) are assumed to occur by collisions of molecules. Thus, were helium used instead of hydrogen, the free-molecular path regime in Fig. 9 would be extended to a higher pressure region.

In this regard, applicants' use of helium as a heat-exchange gas introduced into a concave having a depth in a range of 1 to less than 20 μm has unexpected and nonobvious advantages. Although Mountsier teaches a preferred depth of 20-35 μm (column 10, lines 64-66), the Examiner asserts that those of skill in the art would nevertheless be motivated to use depths of less than 20 μm because the heat transfer coefficient is higher at depths of less than 20 μm , e.g., 5 and 10 μm . While this reasoning may be applicable to use of hydrogen, it does not logically extend to use of helium. The heat transfer coefficient at each gap depth is not shown in Fig. 9 for helium. As discussed above, the free-molecular regime would be extended to a higher pressure region for helium. At a gas pressure of 10 Torr, the heat transfer coefficients at depths of less than 20 μm for helium will not be as high as they are for hydrogen.

Applicant discusses in paragraph [0027] gas conductance of the heat exchange concave. Object temperature is not uniform at concave depths below 1 μm because of low gas conductance. Mountsier, by contrast discusses uniformity of temperature control only with reference to pressure variation (Fig. 14) and

roughness of a wafer surface (Fig. 20). Depth limitation of the heat-exchange concave for uniform temperature control is not disclosed or suggested by Mountsier.

In addition, paragraph [0027] describes how heat-exchange efficiency is reduced if a depth of the heat-exchange concave is over 20 μm . In an ESC where a heat-exchange gas is introduced in a closed space between a chucked substrate and the chucking surface, a pressure in the closed space is practically, for example, 10 Torr. Mountsier also adopts this pressure (column 8, line 10). The attached page 6-46 from the CRC Handbook shows a formula for obtaining the mean free path of each gas. As shown, the mean free path is in inverse proportion to pressure, and the mean free path of helium at atmospheric pressure (1 atm) and 25°C is 20.0×10^{-8} m. Therefore, the mean free path of helium at 10 Torr is calculated as 15.2 μm , because $10 \text{ Torr} = 13.16 \times 10^{-3} \text{ atm}$.

As is known, gas molecules in a state of thermal non-equilibrium shift to a state of thermal equilibrium, i.e., the Maxwell distribution, when a double or triple of mean free time has passed. In demonstration thereof, **the second IDS reference** along with an English translation are enclosed. As described in this reference, collisions of particles move the distribution of those particles towards the Maxwell distribution. Without outer influences, the particle distribution becomes the Maxwell distribution after a double or triple of mean free time has passed. Passage of doubled or tripled mean free time is equal to movement of particles at distances of doubled or tripled mean free path.

In the ESC of the present invention, a molecule of a heat exchange gas receives heat from a substrate when it touches a back surface of the substrate. The molecule travels a closed space between the substrate and a surface of the ESC. Reaching the surface of the ESC, the molecule transfers the heat to the ESC through the surface. In traveling from the substrate to the ESC, if the molecule collides with another molecule two or three times, the Maxwell distribution is achieved and heat is not transferred to the ESC efficiently. Therefore, the length

between the substrate and the surface of the ESC should be smaller than 2-3 times the mean free path of the gas.

In view of this fact, and considering that the mean free path of helium is 15.2 μm at 10 Torr, the inventors have found that the preferable depth range of the heat-exchange concave is 1 to less than 20 μm . This range is specifically tailored to use of helium, and is not disclosed or suggested by any of the references of record. Thus, the rejections under 35 USC 103(a) of claim 33, and claims dependent thereon, should be withdrawn.

Applicant acknowledges that Mountsier mentions helium, but not in conjunction with any disclosure or suggestion that it should be introduced into heat-exchange concaves in applicant's claimed range. Fig. 13 (curve F) shows heat transfer coefficient versus gas pressure using helium. However, the dot height H_D , which corresponds to the gap depth, is explicitly described as being equal to 20 μm (column 11, line 9) Fig. 14 shows temperature profiles of backside pressure drops between the center and edge of a wafer, when helium is used as the backside gas. However, the gap depth with respect to Fig. 14 is not specified. Thus, although Mountsier teaches use of helium, it does not teach introduction of the helium into concaves having a depth of 1 to less than 20 μm .

New Claims

New claims 59-66 depend from claim 33 and recite additional features not disclosed by the cited references, and are therefore patentable in their own right. The patentability of these features has not been asserted in the prosecution of this application to date. In particular, dependent claims 61 and 65 recite:

- a) the gas introduction channels communicate with the gas-diffusion concave at outlets thereof,*
- b) all of the outlets are located off the center of the stage and located on a circumference in coaxial to the center of the stage at every equal angle, and*
- c) each outlet is wider than a width of the gas-diffusion concave.*

Although Mountsier appears to show outlets wider than a width of the gas-diffusion concave (Figs. 10, 15, 17 and 19), the outlet of gas tube 110 is located in the center in all embodiments, and thus is not off center on a coaxial circumference as is also required by claims 61 and 65. As asserted in applicant's response of August 4, 2005, location of the gas outlet in the center causes heat exchange at the center of the object to be insufficient since the gas outlet must be larger relative to off-center multiple outlets. In Yamada, cited in the first office action, the outlets are off-center (Fig. 7). However, gas-introduction holes 42 are not wider than gas-diffusing depressions 24A, 24B, as is required by claims 61 and 65.

The combination of features (a), (b) and (c) of dependent claims 61 and 65 with a heat-exchange concave having a depth in a range of 1 to less than 20 μm , as set forth in base claim 33, provides a synergistic collaboration which is not suggested and cannot be expected from the references of record. As previously discussed, a concave with a shallower depth has a smaller gas conductance. Thus, a heat-exchange concave with a depth of 1 to less than 20 μm has a smaller gas conductance than one with a depth of 20 μm or more. Mountsier's gas distribution channels 74, 74' are used to improve conductance (col. 12, line 46 to col. 13, line 1). However, if many gas distribution channels are used, the central gas inlet port must be enlarged. If enlarged too much, heat exchange will be insufficient and the temperature of the object will become non-uniform at the center.

Yamada, by contrast, employs a plurality of small gas-introduction holes 42 (narrower than gas diffusing-depressions 24A,B. The combination of such small holes with applicant's claimed heat-exchange concave having a depth in a range of 1 to less than 20 μm would cause a shortage of gas to occur at areas apart from holes 42, resulting in object temperature non-uniformity in these areas.

Thus, Mountsier and Yamada each suffer from defects in heat-exchange and temperature uniformity. Moreover, the existence of these defects is not even acknowledged by either reference, so there would be no motivation by one of skill in

the art to combine the reference teachings to solve a problem that is not acknowledged by either reference.

The inventions of claims 61 and 65 are free from these defects and problems. The use of off-center, circumferentially-spaced gas outlets in communication with, and wider than, gas-diffusing concaves, in collaboration with hydrogen gas introduction through the outlets into heat-exchange concaves having a depth in a range of 1 to less than 20 μm , enables highly efficient and uniform heat-exchange between the ESC and an object. This result is unexpected and nonobvious from the combined teachings of the cited references: such collaboration is not disclosed or suggested in any of the references and, moreover, the underlying issues leading the inventors to make this advantageous collaboration are not addressed, appreciated or even acknowledged by any of the references.

New claims 62 and 66 have the additional feature that each lift pin is disposed in each gas introducing channel so that the heat-exchange gas is introduced to the concave only through the gas introducing channel in which the lift pins are disposed. This feature collaborates with a gas outlet wider than the gas-diffusion concave and a heat-exchange concave depth in a range of 1 to less than 20 μm . The gas is introduced from the clearance between the lift pins and outlets, and the clearances are designed so that a sufficient amount of gas can be introduced without causing temperature non-uniformity.

Conclusion

This application is now in condition for allowance. The Examiner is urged to telephone the undersigned to resolve any issues that remain after entry and consideration of this amendment.

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Any fees due may be charged to our Deposit Account No. 50-1314.

Respectfully submitted,
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